Winter Diapause in the Squatter Wasps *Antodynerus flavescens* (Fabr.) and *Chalybion bengalense* (Dahlb.) (Vespoidea and Sphecoidea)

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(*With a plate*)

Antodynerus flavescens and *Chalybion bengalense* are both species of domestic solitary wasps who use pre-existing holes and cavities for their nesting activities. Very often they employ disused nests of two domestic mason wasps, *Eumenes esuriens* Fabr. and *Sceliphron madraspatanum* (Fabr.). We have also seen a nest of *Eumenes conoideus* (Gmelin) being used by an individual of *Chalybion bengalense* for this purpose, and have had this species emerge from a sticky nest, plausibly built by a female *Rhynchium nitidulum* Smith.

In September 1962 we began observations on the nest-building behaviour of *Eumenes esuriens* and *Sceliphron madraspatanum* in Bhubaneswar. Later, we caged in all nests presumed to have been built by these two species that we could find on the front verandah of our house in Bhubaneswar. From none of these did individuals of the presumed builder species emerge. From some, parasites emerged in the same season, and some on dissection contained unidentifiable debris. Most however had been squatted in by members of the two species we are now discussing. These are numbered, D, E, F, H, J, K, L, M, and R in Table I. *E.e.*1 (Table I) is a nest of *E. esuriens* that we watched being built, parasitized by *Stilbum cyanurum* and, after these had emerged, utilised by *A. flavescens* for its own nesting. Taub 1 (Table I)

and Taub 2 (Table II) were nests of *S. madraspatanum* collected from the verandah of another house in Bhubaneswar, for which we thank

TABLE I

Antodynerus flavescens

Nest	Probable builder	Caged	Larva removed	No. of Larvae	Pupated	Emerged	Sex	Length of pupal life (days)
D	*E. esuriens*	18-ix-62	..	1		19-v-63	♂	
			..	2		17-vi-63	♂	
			5-v-63	3	21-vi-63	29-vi-63	♂	8
			..	4		2-vii-63	♀	
E	do.	2-x-62	5-v-63	1	10-v-63	18-v-63	♂	8
			do.	2	22-vi-63	29-vi-63	♂	7
F	do.	do.	do.	1	10-v-63	18-v-63	♂	8½
			do.	2	10-v-63	18-v-63	♂	8½
			do.	3	6-vi-63	14-vi-63	♂	8
H	do.	do.	do.	1	5-vi-63	13-vi-63	♂	8
			do.	2	6-vi-63	14-vi-63	♂	8
			do.	3	22-vi-63	1-vii-63	♀	9
			do.	4	22-vi-63	2-vii-63	♀	10
J	*S. madraspatanum*	26-x-62	do.	1	8-vi-63	..	♀	..
			do.	2	21-vi-63	30-vi-63	♀	9
			do.	3	23-vi-63	2-vii-63	♀	9
K	*E. esuriens*	do.	do.	1	5-vi-63	14-vi-63	♀	9
			do.	2	22-vi-63	30-vi-63	♂	8
L	do.	1-xi-62	do.	1	5-vi-63	13-vi-63	♂	8
M	do.	7-ii-63	do.	1	5-vi-63	13-vi-63	♂	8
R	do.	2-x-62	2-x-62	1	6-vi-63	14-vi-63	♂	8
E.e. 1*	do.	do.	5-v-63	1	10-v-63	18-v-63	♂	8
Taub 1	*S. madraspatanum*	31-xii-62	31-xii-62	1	15-v-63	22-v-63	♂	7½
			..	2		23-v-63	♂	
			..	3		12-vi-63	♂	
			..	4		12-vi-63	♀	
			..	5		14-vi-63	♀	
			..	6		15-vi-63	♀	
			..	7		16-vi-63	♀	
			..	8		19-vi-63	♀	
SR 1	..	14-v-63	14-v-63	1	6-vi-63	15-vi-63	♂	9
SR 2	..	do.	do.	1	8-vi-63	16-vi-63	♂	8
		do.	do.	2	22-vi-63	1-vii-63	♀	9
SR 3	..	do.	do.	1	8-vi-63	17-vi-63	♂	9
		do.	do.	2	21-vi-63	29-vi-63	♂	8
WV	*S. madraspatanum*	26-xi-62	..	1		13-vi-63	♂	

*nest seen being built by *E. esuriens* and being re-used by *A. flavescens* var.

Mr. and Mrs. Richard Taub. SR 1-3 were larvae collected from holes from which bolts had been removed in a door at our house. WV was a nest of *S. madraspatanum* found lying on the ground in the garden of

this house. SDJBN and SDJBS are two brackets of the wall fittings of some apparatus which had been removed, and the 4 screw holes in each of these brackets are regularly used by *C. bengalense* and *A. flavescens* for their nesting. The caging was done either by means of putting a piece of georgette over the nest or by putting the whole nest into a glass jar with a glass lid. The cocoons from SDJBN and SDJBS were put into small corked glass tubes. Those larvae that were removed from their nests and cocoons were also put in similar corked glass tubes. All these glass jars and tubes were put in a glass-fronted wooden cupboard.

TABLE II

Chalybion bengalense

Nest	Probable builder	Caged	Larva removed	No. of Larvae	Pupated	Emerged	Sex	Length of pupal life (days)
SDJBN	..	5-iii-63	5-iii-63	1	21-vi-63	2-vii-63	♀	11
			..	2		25-vi-63	♂	..
			5-iii-63	3	6-vi-63	16-vi-63	♂	10
SDJBS	..	do.	do.	2	6-vi-63	16-vi-63	♂	10
			do.	3	9-vi-63	..	♂?	..
Taub 2	*S. madraspatanum*	31-xii-62	..	1	..	18-vi-63	♂	..
			..	2	..	18-vi-63	♂	..
			..	3	..	29-vi-63	♂	..
			..	4	..	1-vii-63	♂	..
			..	5	..	6-vii-63	♂	..
			..	6	..	19-vii-63	♂	..
			..	7	..	22-vii-63	♂	..
			..	8	..	25-vii-63	♂	..
			..	9	..	25-vii-63	♂	..
			..	10	..	26-vii-63	♂	..

All these larvae were opaque and butter-coloured, had completed feeding, and had spun their cocoons. As can be seen from Tables I and II, the dates of the first pupations observed were 10.v.63 for *A flavescens* and 6.vi.63 for *C. bengalense* and the last emergences in our sample were on 2.vii.63 for the former and 26.vii.63 for the latter.

That both species pupated in several bursts suggests that some climatic stimulus other than day-length provoked this. If day-length were the relevant stimulus only a single peak would be expected.

The Plate gives the daily maximum and minimum temperatures recorded in the cupboard. The humidity figures plotted in this figure were not recorded in this cupboard but were taken indoors and were

supplied by the Commonwealth Institute for Biological Control, Bhubaneswar Station, to whom we are indebted for this facility. It seems from the graphs that temperature is not the factor which causes pupation of the diapausing larvae. Rise in humidity may be the reason, but the last few pupations observed occurred when humidity was decreasing. However, the results appear to point to a common external factor being responsible for pupation in both species.

Table III shows the length of pupal life in *A. flavescens* for the two sexes. There is no overlap between the two distributions, the males having a mean of 7·94 days and the females a mean of 9·125 days. The period considered is that from pupation to emergence from the pupal skin. The wasps fold their wings very soon after this, but we do not know how soon they would nibble their way out of their cells. *Chalybion bengalense*, when they come out of their pupal skin, have the abdomen distended so that the pellets of meconial excreta (Shafer 1949) show through the distended intersegmental membranes between the sternites and tergites as lateral rows of white patches. These pellets are expelled in the course of a day or two. Since wasps emerging in natural conditions do not show these white patches, pupal life was not considered complete until they had disappeared. We saw only three diapausing individuals of this species through pupal life. Two of these, which were males, took 10 days to complete it and the only female took 11.

TABLE III

LENGTH OF PUPAL LIFE IN *Antodynerus flavescens* VAR.

Pupal life (in days) ..	7	7½	8	8½	9	9½	10	Total
No. of males	1	1	12	2	..	..	..	16
No. of females	..	..	..	..	7	0	1	8

From Table IV, we can see that in *A. flavescens* there is a tendency for the over-wintering males to emerge earlier than the females, and in *C. bengalense* there was no overlap, though admittedly the sample is small. The likelihood of getting these results by chance is 1 in 3001 for *A. flavescens* and 1 in 2002 for *C. bengalense*.

We are making much larger collections in the early winter of 1963, and have more cells for which we have laying and sealing records. By dissecting the cells a few weeks after they were sealed, we have already confirmed that diapause is entered during October, after a previous development of a duration similar to that of the non-diapausing monsoon generations.

Thus the species *A. flavescens* has an annual cycle, the individuals being in diapause as late larvae between October and May. This has been confirmed by our notes on when imagines have been seen flying.

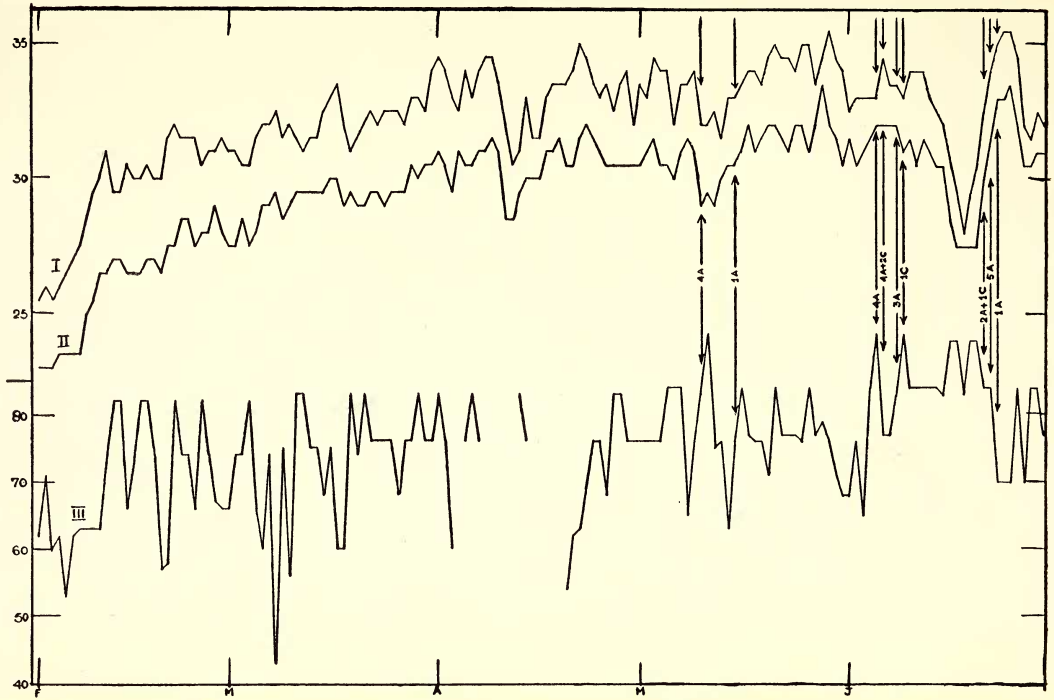
TABLE IV

DATES OF EMERGENCE OF THE TWO SEXES OF *A. flavescens* AND *C. bengalense*

Date	*A. flavescens*		*C. bengalense*	
	♂	♀	♂	♀
18-v-63	4			
19-v-63	1			
22-v-63	1			
23-v-63	1			
12-vi-63	1	1		
13-vi-63	4			
14-vi-63	3	2		
15-vi-63		2		
16-vi-63	2		2	
17-vi-63	1	1		
18-vi-63			2	
19-vi-63		1		
25-vi-63			1	
29-vi-63	3			1
30-vi-63	1	1		
1-vii-63		2		1
2-vii-63		3		1
6-vii-63				1
19-vii-63				1
22-vii-63				1
25-vii-63				2
26-vii-63				1
Total ..	22	13	5	9

In this, as in their proterandrous (Kohl 1918) pattern of emergence, they resemble the solitary wasps of temperate regions (Evans 1963, p. 5). However during their active period, which is the season of most rain in this part of India, there are several generations, i.e. they are multivoltine. The much smaller data presented here would suggest that *C. bengalense* is also proterandrous, and has an even shorter annual period of activity. However this must be a simplification as we have notes of two individuals seen working during the first week of March and a doubtful record for February.

The sample of *S. madraspatanum* nests collected was small and we have in 1963 observed larvae of this species, arising from eggs laid at the end of October, entering diapause. But neither in the much larger sample of *E. esuriens* nests here considered, nor in 5 nests which we



Maximum (I) and minimum (II) temperatures (°C.) and humidity % (III) for the months February-June 1963. Arrows indicate the dates of pupations, numbers indicate number of larvae and letters the two species.